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Fly Ash Used in Foundation for New Power Plant, Weston #4

WISCONSIN PUBLIC SERVICE CORPORATION POWER PLANT FOUNDATION EVALUATION ROTHSCHILD, WISCONSIN

Wisconsin Public Service Corporation - Weston #4 - New Plant Construction

The plans for the construction of the new Wisconsin Public Service Corporation power plant, Weston #4, required stabilizing approximately 10 feet of granular material with Class 'C' fly ash providing a foundation platform for footing construction with a minimum bearing capacity of 400 psi. This design concept had been under consideration as an alternative to piling or caissons beneath the new footings. Significant savings in both cost and construction time were anticipated if the desired strengths could be achieved by stabilizing the native materials.

Mix designs were validated through a series of laboratory design tests. Maxim Technologies of Wausau, WI working with the contractor, James Peterson Sons, Inc. prepared a number of mix design samples for the project. Moisture/density and strength/moisture curves were plotted to determine optimum parameters at various ash and moisture contents. Design strengths were achieved at 20-25% fly ash and 6-8% total moisture. This application is one of the first of its kind using class C fly ash to stabilize granular soils in deep foundation construction.

The Planned Approach

The design firm, Black & Veatch, Inc. along with the WPSC engineering team, discussed the notion of providing a native soil platform under the footings for the new plant using WPS produced class C fly ash as a stabilizing/strengthening agent over a year ago. Many issues were evaluated regarding engineering properties, construction techniques, application and a host of other elements. Once the conclusion was reached that fly ash stabilized [FAS] material could produce the desired strength and load distribution characteristics, the construction methods became the focal point.

The concept for the project was to excavate 15-17 feet of material from the entire foundation site, mix the sand, fly ash and water in a mixing machine [pug mill or other suitable equipment] and deposit the mixture back into the excavation in layers for spreading to a specified depth, compacting it in place and grading it in anticipation of subsequent layers. The total depth of materials placed this way is 10 feet. The approximate dimensions of the excavation are 230' by 350'.

As this approach was discussed and evaluated, it appeared that slow production rates and maintaining quality control would be significant challenges with this method.

An alternative construction concept surfaced which employs a highway pulverizer for mixing, doing the mixing in place rather than outside the excavation, using conditioned ash delivered by open dump trucks [conditioned ash is warm and contains 4-6 % moisture], spread with dozers, graded and compacted immediately after placement and preparing for subsequent layers. Some of the advantages of the approach are faster production rates, fugitive dust control [ash is already wet], warm material during potentially cold weather,

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better bonding between layers and fewer pieces of equipment moving in the relatively confined area at the site.

Construction Operations

The stabilizing project was awarded to James Peterson Sons, Inc of Medford, WI. WK Construction of Middleton, WI and River View Construction of Wausau, WI were selected for pulverizing services and on-site grading/trucking assistance respectively.

Work began in October with the excavation of approximately 30,000 CY of granular material from the foundation site, with walls sloped at 2:1 and grading 2 ramps into the site for equipment access. The material was stockpiled close to the excavation for easy access as it was transported back into the building pad area for stabilization. On Monday, 8 Nov 04 contractors constructed a trial strip to predict production rate, moisture content, hydration time, optimum blending depth, lag time for compaction and other logistical items.

The stabilizing in the excavation began Tuesday, 9 Nov 04 with the first 8 inch layer. After the fly ash was deposited on the sand, it was spread with a GPS equipped dozer, mixed with the pulverizer and compacted with a smooth drum vibratory roller. It is crucial to apply the initial compaction immediately behind the pulverizer. Two passes with the roller was usually sufficient to achieve the required density. Upon completion of this process and density was confirmed, each layer was covered with the subsequent sand layer, ready for stabilizing. The cover material offers protection for the treated layer, retains moisture to assist in the hydration process and can easily be treated with additional water to help achieve the proper composite moisture content for the next layer. Once the contractor perfected the operation, the
production rate increased to 1100 to 1300 square yards [SY] per hour. Equipment consisted of 2 dozers [one to spread fly ash and one to spread sand], 1 pulverizer, 1 vibratory smooth drum roller, 1 tractor/water trailer combination, 1 large bucket loader and a fleet of off-road dump trucks to provide both conditioned fly ash and the subsequent sand layers.

The geotechnical firm providing compliance testing is STS Consultants from the local Schofield office. Monitoring the performance with the Black & Veatch team, STS confirmed that 95-105 % of Proctor density was typically achieved in 1 ½ hours or less. Initially, tests for both moisture and density were performed every 15-20 minutes to assure that the performance requirements were met. Moisture content of the mixture is critical.

It became clear that weather, moisture content, fly ash concentration, mixing rate / depth and lag time to final compaction were all key, interrelated elements to performance. Each element needed to be watched carefully as the process went forward. Cool temperatures, rain and wind needed to be monitored regularly. One engineer noted that the light rain that fell occasionally during the course of the work actually enhanced the operation.

As the project advanced, production continued to improve, specification compliance became easier to achieve, and both engineers and contractors became more comfortable with the process. It was estimated that the entire stabilizing component of this project would be complete in approximately 15 working days. It was also estimated that upwards of 15,000 tons of fly ash would be required, most provided by WPS from both the Weston and Pulliam

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[Green Bay] plants, but some additional material was required from Alliant Energy from the Columbia plant near Portage.

Interim Evaluation

At approximately 75% completion of the stabilizing, the Wisconsin Department of Natural Resources [DNR] evaluated the process, the interim results, the progress, specification compliance, and the environmental efficacy of this unique application for FAS. The results of the discussion and field observations were outstanding. Strengths of up to 600 psi were commonly achieved, and production rates were excellent. While observing the process in the excavation, it was clear that the use of conditioned [pre-wetted] fly ash was significantly better than other spreading methods commonly used. Even spreading the newly placed fly ash with a dozer produced absolutely no fugitive dust. Clearly the DNR representative found the dust free procedure to be very attractive from an environmental point of view.

Post Construction Evaluation

The stabilizing of the new plant foundation was completed November 29, 2004. Construction of the footings began later that week. Equipment, forming materials, cover blankets and other supplies were assembled on the site and the work began. During the transition period, several key engineers, managers and contractors were interviewed to assess the efficacy of this technique.

Washington Group International, Inc is providing construction management of the Weston 4 project. W.T. 'Bill' Scarlata, the WGI civil construction manager, who had not experienced constructing a FAS foundation in the past seemed very pleased with the process and the results. He indicated that there were very few problems with either the application or the techniques.

Only a few small areas needed to be re-stabilized, but he pointed out that in those areas performance changed, likely due to a change in the fly ash source.

Constructing a FAS sand foundation was a first experience for James Peterson Sons, Inc. as well. Unknown production rates, coordination of materials deliveries and sources, hydration times, compliance testing and performance created some apprehension for them prior to commencing the work. The apprehensions disappeared as the operations went into high gear. During a post-completion discussion with David Funk, James Peterson Sons superintendent, he eagerly shared his views of the process. He indicated it was his first experience stabilizing soils with fly ash. He found that using cement in a similar application did not work, so he was pleasantly surprised with the performance of the fly ash. Funk said, "It was easier than I thought it would be. It went very smoothly, but paying strict attention to details such as water content, mixing times and zero lag time to initial compaction was crucial." Funk quickly learned that the process did vary some with fly ash sources and attendant quality, but close observation of materials and close coordination with the soil test engineers assured contract compliance. He offered that another advantage of this technique is that the conditioned fly ash comes to the site in the temperature range of 95 to 100 degrees F. In November in Wisconsin, that's a real plus. Asked if he would undertake another large project like this, he responded: "You bet!"

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Environmental and Safety Evaluation

Early in the planning for this project, the alternative methods of delivering and spreading the fly ash were explored and evaluated. Extracting warm, moist conditioned fly ash directly from the plant silos, transporting it directly to the work site for spreading and mixing found favor among the planners. It was perceived to be better than the more typical delivery method, which employs spreading cool, dry fly ash with a controlled hopper truck and adding moisture during the mixing process. The preferred alternative proved itself throughout the project. There was virtually no fugitive dust on the stabilization site.

This was of particular importance to Ron Demulling, safety engineer for James Peterson Sons. Demulling is responsible for monitoring employee safety on project sites. He was very pleased with the absence of dust. Other employee safety benefits of note are that other than occasional soils test technicians, the only employees in the work area were equipment operators. No manual material handling is required and with the GPS controlled dozers, no staking to control grades is needed. Fly ash and sand were spread to proper depth by the dozers.

Conclusions

Constructing a strong, massive FAS foundation by mixing native soils [sand in this case], conditioned class ‘C’ fly ash in a closely controlled work environment with appropriate design requirements, equipment and performance monitoring is a very new, but extremely effective technique. Black and Veatch engineers have designed the foundation for another component of the new plant using the same technique. That might require upwards of 1,000 tons of fly ash. Contractors indicated that they find the method so smooth they would definitely use it again.

The technique is environmentally superior to others, considering employee safety, ambient air quality, and impact on contiguous landmass. Furthermore, engineers anticipate that over time, the FAS material will continue to gain strength, significantly exceeding the 600 psi recorded during compliance testing. It has clear advantages [inherent heat and moisture content] for heavy construction during early winter in cold climates like northern Wisconsin; it is not adversely affected by seasonal rains; in embankment construction, there are no delays between construction of multiple layers and it is cost effective. On this project, FAS versus pile construction saved approximately 35% of estimated cost and several weeks of construction time.

As the engineering and contracting communities become more familiar with the advantages of FAS foundation construction, it has the potential to increase in popularity. And the use of conditioned ash, delivered and spread with open dump trucks, especially on large, closely controlled projects will gain in popularity.

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